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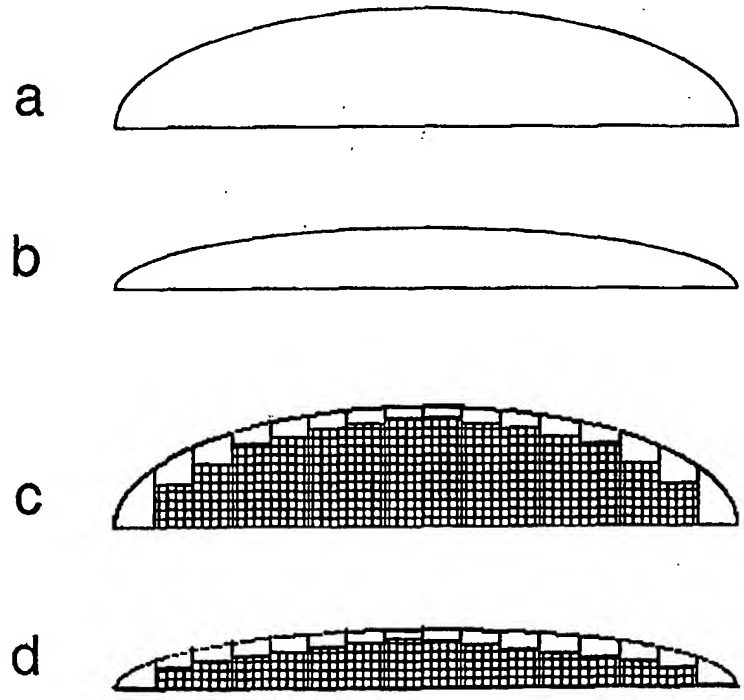
(54) Title: LENS WITH VARIABLE FOCAL LENGTH

(57) Abstract

The present invention relates to a lens with variable focal length, which besides can change very rapidly between different focal lengths. This is achieved by the lens being composed of at least two sets of partial surfaces, all partial surfaces in a given set being portions from one and the same imaginary Fresnel lens with a predetermined focal length and the focal lengths differing between the different sets, and an aperture, which is adapted to permit, at every moment, masking of all partial surfaces except those included in a given set, the aperture being adapted to be able to change between letting radiation through the different sets.



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Lens With Variable Focal Length

The present invention relates to a lens with variable focal length.

In many optical applications it would be advantageous if a lens were available which could rapidly change between a number of different focal lengths. It is known to change between different lenses by means of an electromechanical device. Such a device, however, does not satisfy the rapidity requirements in many applications. A lens consisting of liquid between two plastic surfaces, the inward or outward bending of which can be controlled by controlling the pressure of the liquid, is also known. Also this construction is not sufficiently rapid and accurate for certain applications.

The object of the invention is to provide a lens having the desired properties, which is achieved by giving the invention the design that is evident from the appended independent claim. Suitable embodiments of the invention are stated in the remaining claims.

The invention will now be described in more detail with reference to the accompanying drawings, in which

Figs 1a - 1g are side views showing how an inventive lens can be composed of two imaginary Fresnel lenses,
Fig. 1a shows the one imaginary original lens, lens A,
Fig. 1b shows the other imaginary original lens, lens B,
Fig. 1c shows lens A, removed parts being marked,
Fig. 1d shows lens B, removed parts being marked.
Fig. 1e shows lens A as Fresnel lens,
Fig. 1f shows lens B as Fresnel lens,
Fig. 1g shows the assembled Fresnel lens,
Fig. 2a shows the lens in Fig. 1g seen in the direction of radiation,
Fig. 2b shows, compared with the lens in Fig. 2a, an alternative embodiment of the inventive lens,
Fig. 3 shows the lens in Fig. 1g with an aperture in the form of a layer of liquid crystal,
Fig. 4a shows an embodiment of a planoconvex lens according to the invention,
Fig. 4b shows an embodiment of a biconvex lens according to the invention, and

Fig. 4c shows an embodiment of a concave-convex lens according to the invention.

By building a lens from partial surfaces of two or more imaginary lenses with different focal lengths, it is possible to construct a lens having several focal lengths. An obvious drawback of such a single lens is that images cannot be focused sharply since two or more images, of which one, at most, is sharp, will be overlapped.

One way of obviating this drawback is to mask the partial surfaces, the focal length of which does not conform with the desired. The intensity of light will, of course, decrease proportionally to the number of covered partial surfaces, which in many cases is disadvantageous. In certain applications, however, this is of no import. Under certain circumstances, it may even be an advantage that the intensity of light decreases.

One method of masking partial surfaces, which is relatively simple and besides can take place at a high frequency, is the using of an aperture in the form of liquid crystal. Such an aperture, the transmittance of which to the different partial surfaces can be controlled electrically, makes it possible to construct a rapid, electrically controlled lens having a variable focal length.

An advantageous technique of preparing a lens according to the invention is to assemble a lens from two imaginary Fresnel lenses. A Fresnel lens is a lens which is divided into a number of partial surfaces, usually annular, the refracting outer surface of which has been maintained while eliminating plane-parallel blocks from the interior thereof. The removed parts have no effect on the refractive power of the lens since the radiation is refracted only in the interfaces with the surroundings. By removing lens material, the lens decreases considerably in respect of volume and, thus, in respect of weight. A common, generally known application for Fresnel lenses is in overhead projectors.

Two Fresnel lenses with different focal lengths can at first glance seem identical since it is difficult to see the difference of the radius of curvature of the thin refractive partial surfaces, which, as mentioned above, usually are annular. However, the partial surfaces need not look like circles, but may have a different design.

Figs 1a and 1b show two ordinary lenses, A and B, with different focal lengths. Below them, in Figs 1c and 1d, the parts that are removed when making the

corresponding Fresnel lenses have been marked. Figs 1e and 1f illustrate the corresponding Fresnel lenses, and Fig. 1g shows an assembled lens, in which every second part comes from lens A and from lens B, respectively. This lens seen in the direction of radiation is shown in Fig. 2a, the parts coming from lens A being designated 1 and those coming from lens B being designated 2.

Fig. 2b shows in an alternative embodiment how parts consisting of parts of rings can be assembled to a lens. Also in this case, parts from lens A are designated 1 and parts from lens B are designated 2.

It goes without saying that it is possible to use more than two Fresnel lenses, when necessary. Besides, as mentioned above, the parts need not at all be annular as shown. Many other shapes of the various partial surfaces are conceivable.

Fig. 3 shows an embodiment of the invention with an aperture layer 3 of liquid crystal. In the lower part of the Figure the device is seen from below, i.e. the liquid crystal layer is to be seen. 4 designates the layer of liquid crystal which masks surfaces coming from the imaginary lens B. 5 designates the layer of liquid crystal which masks surfaces coming from the imaginary lens A. In connection with the appearance of the Figure, it may be seen to show a situation the moment when the layer 4 of liquid crystal is opaque and the layer 5 is transparent. This means that merely lens parts from the imaginary lens A refract the radiation towards their focus.

Figs 4a, 4b and 4c, respectively, illustrate embodiments of the invention consisting of a planoconvex lens, a biconvex lens and a concave-convex lens, respectively.

Claims:

1. A lens with variable focal length, c h a r a c t e r i z e d in that it is composed of at least two sets of partial surfaces, all partial surfaces in a given set being portions from one and the same imaginary lens with a predetermined focal length and the focal lengths differing between the different sets, and an aperture which is adapted to permit, at every moment, masking of all partial surfaces except those included in a given set, the aperture being adapted to be able to change between letting radiation through the different sets.

2. A lens as claimed in claim 1, c h a r a c t e r i z e d in that the lens is a Fresnel lens.

3. A lens as claimed in claim 1 or 2, c h a r a c t e r i z e d in that each set consists of a number of circular rings, circular rings from different sets adjoining each other in the radial direction.

4. A lens as claimed in claim 3, c h a r a c t e r i z e d in that each set consists of a number of circular annular parts positioned in circle sectors, circular annular parts from different sets within each circle sector adjoining each other in the radial direction and annular parts from different sets adjoining each other at the sector boundary lines.

5. A lens as claimed in any one of the preceding claims, c h a r a c t e r i z e d in that each set of partial surfaces occupies an essentially equally large part of the lens surface.

6. A lens as claimed in any one of the preceding claims, c h a r a c t e r i z e d in that the aperture is designed as a layer of liquid crystal with different zones covering the different partial surfaces, said zones being arranged in a prior-art manner to be either transparent or opaque.

Fig 1a

Fig 1b

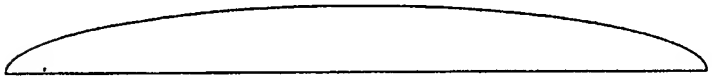


Fig 1c

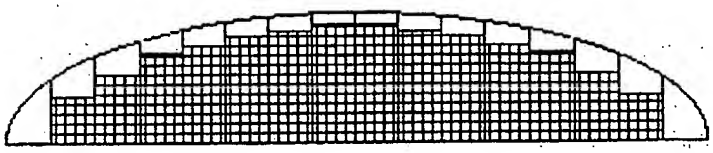


Fig 1d

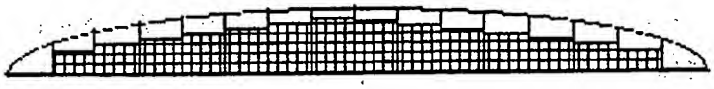


Fig 1e

Fig 1f

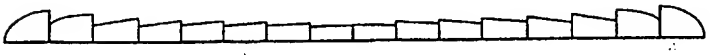
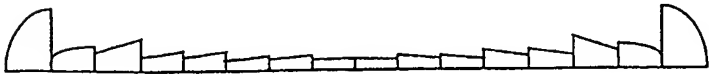


Fig 1g



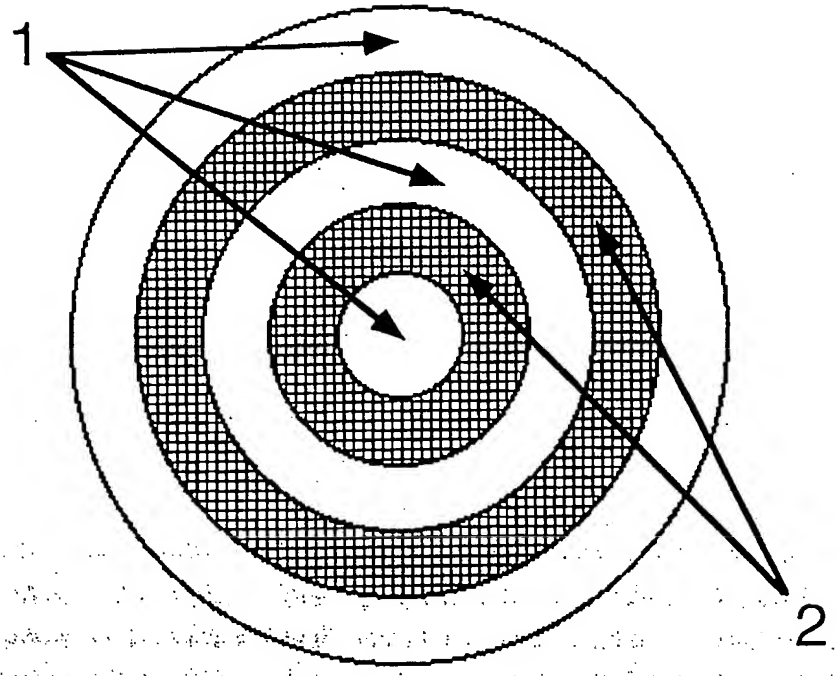


Fig 2a

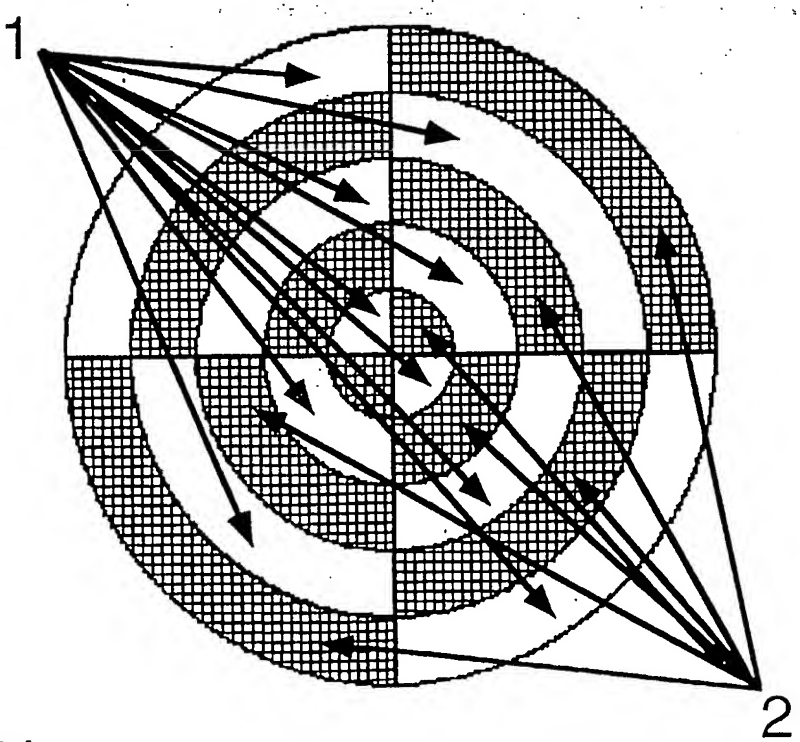


Fig 2b

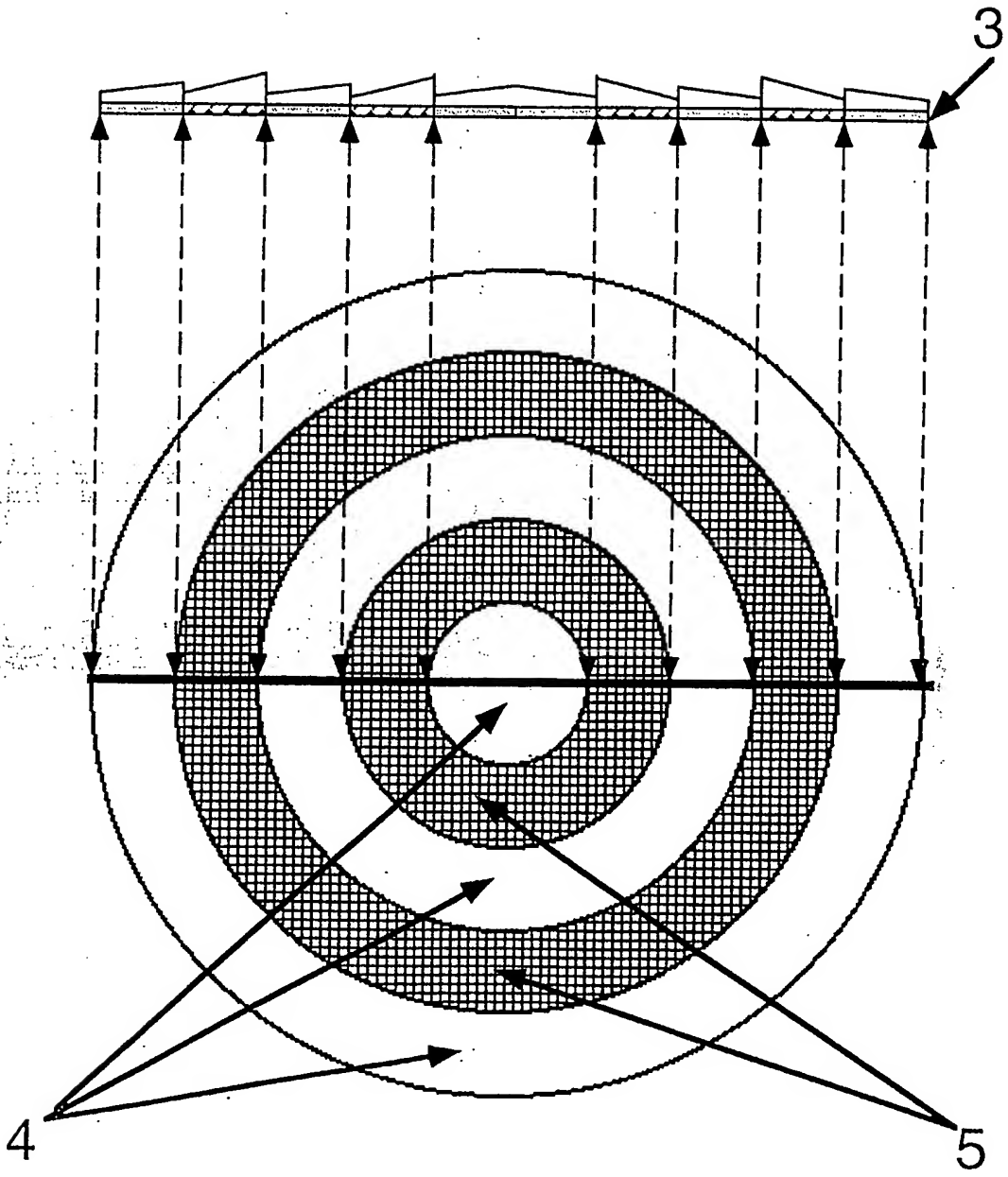


Fig 3

Fig 4a

Fig 4b

Fig 4c

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/02142

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G02B 3/08, G02F 1/13
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G02B, G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4601545 A (SEYMOUR P. KERN), 22 July 1986 (22.07.86) --	1-6
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